Research Evaluation, 28(1), 2019, 51–62
doi: 10.1093/reseval/rvy039
Advance Access Publication Date: 19 December 2018
Article

OXFORD

Challenge-led interdisciplinary research in practice: Program design, early career research, and a dialogic approach to building unlikely collaborations

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Abstract

Challenge-led interdisciplinary research is a relatively new way of bringing together disciplinary expertise in response to complex societal and environmental problems. Common difficulties include how to define 'interdisciplinary research'; how to improve the participation and flourishing of early-career researchers; and how to manage projects with disparate teams of researchers while deepening external collaborations. This article reports from a major initiative of this type. It interrogates qualitative data generated from program evaluation among participating researchers, identifying insights on beneficial structural (program design) and 'soft' infrastructure (human capital) variables, as well as on-going barriers and tensions. Notwithstanding the difficulties of communicating and collaborating across epistemic domains, the program in question exceeded expectations in building interdisciplinary research and early research careers—though not necessarily in ways initially imagined. Staggered funding pools meant it was acceptable in early phases for low-cost projects to 'fail safely', while strict funding guidelines on distal interdisciplinarity compelled unlikely and novel researcher combinations and projects. Moreover, such program design features 'granted permission' to early-career researchers to approach more senior, cross-faculty researchers as potential collaborators, hence building leadership capacity. Human capital variables included a dialogic approach to project development ('curating' projects as they evolve), inclusive program leadership, and promotion of the benefits of a collaborative rather than competitive research culture. Distal interdisciplinarity not only nourishes novel and unlikely research projects that respond to complex problems; with good program design and meaningful relationships it can, we argue, also build research careers differently from an early phase.

Key words: distal interdisciplinary research; challenge-led funding; dialogism; early-career researcher.

1. Introduction

It is now widely established across the higher education sector that new approaches to building interdisciplinary research capacity are needed, bringing together the disparate expertise needed to solve complex problems (Roelofs et al. 2018). In this light, funding agencies internationally are adjusting programs, curating their funding calls around defined 'challenges'. Among the more prominent is the Research Councils UK 'Global Challenges Research Fund', an initiative led by the Department for Business, Energy and Industrial Strategy (BEIS), which seeks to generate challenge-led disciplinary and interdisciplinary research addressing identified themes. Funding is awarded to hubs on the basis that they fit with the UK's Official Development Assistance (ODA) guidelines, with a primary purpose to promote the economic development and welfare of a developing

country or countries (Research Councils UK 2018). In Australia, from where we write, the national strategic research priorities have likewise been framed around a small number of key 'practical research challenges'. Such shifts mirror the approach first established by private philanthropic foundations such as the Bill and Melinda Gates Foundation that issue rounds of funding tied to certain humanitarian goals.

A vanguard of universities are accordingly reorganizing whole-of-university research management efforts towards challenge-led (or 'problem-led') research. Examples of this include the University College London's Grand Challenges, Warwick University's Global Research Priorities, Delft University of Technology's Research Initiatives Program, and Princeton's Grand Challenges. Such programs seek to bring researchers together under a common goal to address specific research issues. This article reflects on such a program, operating in the Australian higher education context since 2013: the University of Wollongong's Global Challenges Program. The program, whose title and guidelines strongly echoes the language of interdisciplinary challenge-led research, brings scholars together in novel combinations to develop ambitious projects that respond to identified research needs.

The aim of this article is to provide insights from this experience—an experiment conducted on the scale of an entire university. It stresses the importance of managing and funding research differently so as to harness expertise and build careers and research capacities across multiple specialities while drawing attention to limitations and difficulties. Below, we draw upon descriptive and qualitative data generated in evaluations of the program by participating researchers, to identify program design and 'soft infrastructure' (human capital) features that proved beneficial, as well as to identify barriers to ongoing growth and engagement. As we detail, participating researchers identified a beneficial combination of program design for 'distal interdisciplinarity' (Yegros-Yegros, Rafols and D'Este 2015)—i.e. combinations of researchers from very different backgrounds—and 'dialogic' leadership (Russell and Kelly 2002) while discussing difficulties and ongoing tensions linked to career expectations, discipline traditions, and teamwork and interpersonal communication conflicts (cf. Cheruvelil et al. 2014). Of particular note, we discuss how program guidelines intended to promote more distal researcher combinations also underpinned greater degrees of engagement and successful outcomes among early career researchers than was expected, thence building leadership skills. Distal interdisciplinarity not only enables research projects to respond to societal problems in a more complex funding landscape; with the right combination of program design and dialogic leadership it also, we argue, holds the potential to build careers differently from established norms.

2. Interdisciplinarity as a means to respond to global challenges

Debates regarding the need for, and the benefits of, interdisciplinary research are nothing new (Grigg 1999; Bammer 2012). It is now a truism that complex 'wicked' problems cannot be solved by any one discipline in isolation (Brown, Harris and Russell 2010). Although most researchers would, if pressed, instinctively recognize this, the manner in which universities and governments increasingly scrutinize, reward, and recognize individuals for high-quality research, can work against riskier larger-scale interdisciplinary projects and longer-term external collaborations geared towards solving societal problems (Burrows 2012; Cupples and Pawson 2012). Definitional problems abound (Aram 2004).[1] In the Australian context an interdisciplinary project could satisfy the Australian Research Council's current definition with reference to formal Field of Research (FoR) codes (Australian Bureau of Statistics 2008). However, with multiple FoR codes overlapping across high-level knowledge groups, too much scope exists for projects to be made to appear interdisciplinary, when in practice they have brought together proximal researchers of similar epistemic persuasion (Yegros-Yegros, Rafols and D'Este 2015). The multiplicity of funding agencies, foundations, national research bodies, and internal university research schemes, each with accompanying guidelines, amplifies such ambiguity. Among the varied metonyms adopted by universities, funding agencies and government administrators are 'interdisciplinary', 'multidisciplinary', 'transdisciplinary', and 'postdisciplinary research' (Coles, Hall and Duval 2006; Bammer 2013; Frodeman, Klein and Pacheco 2017). None of these perfectly define interdependent research efforts across disciplines nor eloquently counterbalance specialism with generality—though all certainly capture the zeitgeist.

Meanwhile, disciplinary parameters for career development are well entrenched (e.g. promotion ladders that reward swift publications in highly ranked journals). Building trust across epistemic domains requires time and emotional work, as does finding a common language across fields, and deepening engagement and collaboration with external organizations (Jackson and Crabtree 2014; Crabtree 2017). Interdisciplinary research takes longer to identify collaborators, execute the research plan, obtain results, and find a suitable journal to publish the findings (Bromham, Dinnage and Hua 2016). There is mixed evidence, too, on whether papers referencing disparate fields are more or less cited. Larivière, Haustein, and Börner (2015) found positive evidence, with fewer citations assumed to be due to the 'quality' of the papers. For Yegros-Yegros, Rafols, and D'Este (2015), the lack of citations to interdisciplinary papers can either be due to quality or the audience. In many quarters, scientific audiences 'are reluctant to cite heterodox papers that mix highly disparate bodies of knowledge' (Yegros-Yegros, Rafols and D'Este 2015). The prevailing wisdom is to build disciplinary careers first and contemplate interdisciplinary research only later.

Following initial waves of impetus around interdisciplinary research that have arguably delivered only modest successes (Bromham, Dinnage and Hua 2016)—and confronted with a host of structural and cultural barriers to such research—government and philanthropic funding agencies and, increasingly, universities around the world have turned to 'challenge-led' approaches. Unlike the approach taken by scientific research councils to promote interdisciplinary research for its own intrinsic sake, challenge-led interdisciplinary research programs frame research priorities around solving specific (but complex) social, environmental, or economic problems. The growing trend is away from open application processes, towards annual funding rounds accompanied by a call for proposals addressing specific problems (e.g. water quality, reproductive health, and dementia) and engaging more closely with external stakeholders (Pells 2018). Interdisciplinary research geared towards such identified challenges is one means of rebalancing priorities to better accommodate translational impact, external engagement, and collaboration (cf. Crabtree 2017). Often the problem is not convincing researchers to contemplate interdisciplinary or externally facing research projects, but to find ways to align research with existing proclivities and motivations, and to cultivate interdisciplinary and

external engagement in a grass-roots, researcher-led fashion (Klein 2008). Funding agencies are increasingly setting a tighter agenda around the research they want done, but at stake are values of academic freedom, the importance of 'blue sky' foundational research, and ultimately, competing values of reputation for rank promotion, disciplinary visibility, and esteem, as research careers grow.

In the past decade, there have since been various institutional attempts within universities to re-organize efforts towards challenge or problem-led interdisciplinary research, with varying levels of complexity, uptake, and productivity (National Academies of Science 2010). An umbrella approach, for instance, occurs when a university or research organization maps their existing research expertise under a common area or theme, and subsequently rebrands a grouping of collected researchers/projects in line with a stated societal goal (Feller 2007). Existing research/projects are effectively 'white-labelled', and there is often no significant new funding attached to this rebranding, or new research endeavours undertaken. While researchers from a number of disciplines contribute their research to address the overarching goal, they do so often in isolation but in parallel, within separate disciplines (what Klein 2008 terms 'multi-disciplinarity'). This approach stems from the understandable desire to clearly and concisely corral what is otherwise highly diverse research, and to assist universities in marketing their research or associated fundraising campaigns. Yet, in instances when researchers operate in complete isolation, on distinct projects merely gathered under the same umbrella ostensibly for communication purposes, the model is not even 'multi-disciplinary'—little more than a virtual coalition of single disciplinary teams.

Another approach is to realign research structures away from disciplinary specialisms into interdisciplinary groupings. A bold example of this approach was the 2003 organizational restructure of the Australian Commonwealth Scientific and Industrial Organisation (CSIRO) and subsequent formation of a series of Flagships as new research entities (Australian National Audit Office 2011). In this model, an entire workforce and line management structure was reorganized to re-locate otherwise disparate researchers into new proximate combinations, and to orchestrate or re-engineer future possible collaborations (Sandland and Thompson 2012). New groupings and physical relocations effectively force researchers to work together. An issue with this approach, however, is that the newly reconfigured structure eventually mimics the single-discipline 'silos' it replaces. Over time new entities risk inheriting the weaknesses of the disciplinary structure (isolationism and non-cooperative positioning) while fragmenting and disrupting deep specialist expertise. The novelty gained from combining researchers of diverse backgrounds fades over time into familiar proximity (cf. Davids and Frenken 2018). Constant restructuring and reforming of departments and entities would be required to maintain constant mixing of difference while best positioning institutions to funding agencies' evolving priorities and latest rounds of identified challenges—but that is impractical and unpalatable. Moreover, in the university setting, where academic freedom is the core currency and lifeblood, researchers baulk at attempts to have their research agendas dictated to them from such institutional rearrangements.

In what could be described as a 'hybrid model', some universities maintain their discipline-aligned faculty structure while creating additional dedicated interdisciplinary research institutes. Notable successful models include Durham University's Institute of Advanced Studies (IAS), Stockholm Environment Institute, Oxford University's Future of Humanity Institute, and in Australia, RMIT's Centre for Global Research and the University of Sydney's Charles Perkins Centre. Such research institute's may have line-management responsibility over staff, or they may constitute a coalescence of researchers from an array of home faculties that move in and out of the institutes as required. An advantage of this model is that it can bring researchers from different disciplines to work together daily, sharing responsibilities and meetings in an atmosphere of collegiality within a physical institute or building (Strang and McLeish 2015; Strang 2016: 14–15). The risk is that, similar to a whole-of-organization restructure, developing stand-alone centres for translational and/or interdisciplinary research may over time compartmentalize such research.

This article describes and evaluates another approach: responding to societal problems via a university-wide program dedicating significant resources to build more radically interdisciplinary groupings while retaining existing disciplinary faculty/department structures. Radical interdisciplinarity (also known as 'long-distance' or 'distal' interdisciplinarity—see Larivière, Haustein, and Börner 2015; Yegros-Yegros, Rafols, and D'Este 2015) brings together researchers *without* a 'natural fit': who do *not* previously envisage working together. In the University of Wollongong's case, it also involved participation of researchers who are not relocated from existing disciplinary bases to do so. The research program discussed here sought to promote such distal, radical interdisciplinarity while preserving the disciplinary units of the University within which researchers feel a strong sense of belonging. The challenge then was to envisage what kind of research management structure, program design, guidelines, and cultural settings are required to foster serendipitous interdisciplinary projects in response to societal problems—working beyond faculty silos while anticipating a funding landscape increasingly geared towards constantly evolving, annual rounds of tightly proscribed themes. As discussed below, the resulting program combined design elements (guidelines) and human capital variables (leadership and management styles) to promote distal interdisciplinary research and external collaboration—and succeeded in catalysing highly novel projects bringing together unlikely collaborators. What especially surprised the university was the extent to which the program also met goals to build research leadership and promote early career researchers, in unanticipated ways.

2.1 Background to the University of Wollongong's Global Challenges Program

In July 2013, after an extensive period of development and university-wide engagement, the University of Wollongong launched its interdisciplinary challenge-led research program. Its launch observed and responded to the changing language and new research initiatives emanating from the European Union (EU) and UK. A lengthy process was undertaken to identify a select set of challenges that would appeal to researchers, where there was disciplinary expertise, and genuine local and global need. A working party was established with high-level authority (chaired by the Vice-Chancellor) and a breadth of disciplinary expertise and representation from all levels of academia. Researchers at the University were surveyed to identify challenges that they felt were important and that aligned with existing strengths—which was consistent with the philosophy of making interdisciplinary research work within, around, and beside existing structures. National research priority statements and United Nations development goals were mapped against local expertise. Draft challenges were then open to the full university community for feedback and review, before receiving endorsement from the university council for an initial period of five years. From its inception to launch, identifying and developing

the program and its specific research challenges took approximately 18 months.

Gauging researcher responses against available university resources centrally, the decision was made to focus on three challenges—addressing issues of an ageing society, dynamic industries and technologies, and coastal and marine environmental sustainability—unified within an overarching, larger challenge expressed in the language of social and environmental transformation.

The challenges evolved through a balance between two conflicting desires: to include as many productive research disciplines as possible; and to keep the challenges focused and meaningful. In addition, and pertinent to the decision-making process, the university operates in a region with a strong manufacturing heritage, a delicate coastal zone, and an aging population. So ultimately, the challenges that emerged were not only globally significant problems but all had a specific relevance to the local region (aligning with the university's strategic planning goal to serve its geographical setting and communities of interest). The final set of agreed challenges—Living Well, Longer; Manufacturing Innovation; Sustaining Coastal and Marine Zones—was carefully worded: necessarily focused, but also broad enough that they could encompass internal diversity of projects geared towards funding agencies' annual rounds and shifting priorities. The program's finalized goals were to:

- generate and apply knowledge to effect transformational change, both within the local region and globally;
- build the university's capacity and reputation as an agent for change with tangible benefits to the community;
- develop and enhance multidisciplinary collaboration between groups of researchers across boundaries;
- support multidisciplinary projects that enhance our ability to respond to the priorities of funding bodies and lead to successful larger, external funding applications; and
- nurture and encourage the careers of early career academics and research students by promoting a sense of boarder relevance and collaboration.

The program is led by a team consisting of senior academic and professional staff: a program executive director and three challenge leaders who are active professorial (Level E) researchers (appointed to the program through a competitive internal process, but who retain their substantive Professorship in their 'home' school/faculty), and a full-time program director—a senior professional staff appointment (who also holds a PhD and has prior experience establishing major research initiatives) to manage the program's operations and guides its strategic direction.

From the outset, the leadership team sought to establish the program to operate in a way in which researchers across the university could feel a sense of ownership. The vision was for researchers to guide the intellectual development of a program that would find, and fund, researchers with good ideas and a keenness for collaboration and make it easy to undertake research—and to refrain from dictating what preferred projects should be. Researchers across the university remain line-managed within faculties, schools, and centres and continue to undertake basic disciplinary research. Meanwhile, the program sits apart from faculties and schools, in effect, a free-floating program, reporting directly to the Deputy Vice-Chancellor, Research and Innovation (DVC R & I). As a consequence of this structure, the success of the program rests with its ability to entice researchers to extend beyond their domains: 'carrots' rather than 'sticks'.

Meanwhile, taking the goal to promote early-career research (ECR) capacity seriously meant overcoming the commonly held view that that interdisciplinary research is disadvantageous for ECRs who have yet to establish a deep disciplinary reputation (McLeish 2016). The program sought to improve ECR engagement by incorporating an ECR representative onto the program's decision-making board (overseeing funding decisions), and explicitly prioritizing projects with strong ECR participation, if not outright leadership, in funding guidelines. Program leaders made very clear in communications via town hall meetings and workshops that ECR-led projects would be favourably received (and likely rank higher than senior-researcher-led projects with only secondary ECR participation). Other special measures included annual promotions of 'next generation' research leaders in special events and publications, and incorporation of new categories of interdisciplinary research excellence into the Vice-Chancellor's annual staff awards, as incentives.[2]

As illustrated below, promotion of early career researcher participation in interdisciplinary research also benefited from another novel—and controversial—feature of the program not originally geared to that end: its insistence from the outset on distal interdisciplinarity (cf. Yegros-Yegros, Rafols, and D'Este 2015): a high degree of difference in the combination of researchers who work together on supported projects. All project teams supported through the program must be deeply varied—defined in terms of broad fields of knowledge. The university has only five faculties (Engineering and Information Sciences; Science, Medicine and Health; Social Sciences; Law, Humanities and the Arts; and Business), and yet a minimum of *three* faculties must be represented in the researcher teams as a basic condition of funding. From the outset, in official guidelines, and in communications from the program's leadership team (including 'town hall' style meetings to launch the program on campus), it was made very clear to researchers that genuinely novel researcher combinations were preferred, even to the point of favouring those who have never worked together previously. Meanwhile, the consistent messaging was that proximal interdisciplinary projects and 'teams of convenience' would be unlikely to succeed in gaining funding. Ranking of funding applications would also favour those projects with a clear sense of external opportunity, and identification of likely or existing partner organizations.

Commensurate with such intents, application processes were adjusted to emphasize researcher engagement, novel ideas, distal interdisciplinarity, and a dialogic or curatorial approach to project development. The latter was particularly significant. Dialogic approaches to research development emphasize

> synergistic communication between or among participants. Because this approach relies on ideas about dialogic communication, it carries an intrinsic investment in the reflexivity of every conversant—i.e., every researcher and every participant. It emphasizes the reflexive value of conducting research in the context of a team of researchers, and it examines the role of reflexivity at each step of the research endeavor: formulating the question, gathering information, analyzing this information, collaborating with other researchers, and 'returning' the fruits of the research to participants. (Russell and Kelly 2002: 1)

In this case, unlike funding programs that refrain from interacting with researchers prior to assessment due dates, participating researchers are encouraged to contact challenge leaders prior to and during the development of project teams. Dialogues between funder

and researchers emerge very early in the process of ideas generation: both within the university (i.e. with Global Challenges Program leaders) and beyond (e.g. integrating external stakeholders into grant applications as partner investigators). Funding was structured around tiers of low-level strategic ($5,000), seed ($15,000), and project funding ($50,000 p.a. for up to 3 years). At all levels, the 'three-faculty rule' applies. At seed level, projects are not expected to have secured external partner organizations, though many do indeed forge external relationships at the outset (with some projects receiving seed funding only after researchers have been approached from an external organization). For higher levels of funding, teams are expected to have secured the collaboration of external agencies and/or external funding. Subsequently, the challenge leaders in effect act as 'brokers' or 'match-makers' across faculties, and with external organizations: suggesting names of people to contact who could be potential collaborators, or advisers, to a project. Ideas are curated among researchers, external collaborators, and challenge leaders prior to the submission of written applications. Those written applications are in a format kept short, to minimize bureaucratic burden, while ultimate decision-making on successful grants is guided by performance in a short 'pitch' to the program's leadership group, as well as an accompanying interview. Frequently, representatives of external partner organizations attend final interviews, where they have the opportunity to articulate the benefits of the proposed research to the ranking committee. Again, the assessment procedure follows the logic of dialogism, rather than 'hands-off', paper-based administration.

As a means of monitoring and ensuring the achievement of its founding objectives, the program seeks feedback and consequently reviews funding opportunities and implementation. Some 18 months into the program, researchers were invited to respond to an initial, succinct evaluation, with feedback guiding improvements. The findings reported in this article are based on another, more detailed feedback and evaluation process conducted at the start of 2017, 4 years into the program's operation, in anticipation of the first 5-year term coming to an end, and subsequent external review and refinement for a second term of funding.

3. Methods

Prior to the commencement of data collection, approval was granted by the university's Human Research Ethics Committee (HE2016/995). A combination of descriptive quantitative and open-ended qualitative instruments was drawn upon to meet research objectives, which were largely exploratory. First, in February 2017, an online survey was sent via by email to all researchers who could potentially have applied for program funding (~600). This was accompanied by a cover letter which explained to participants the purpose of the study and also assured them that participation would be both confidential and anonymous. The survey yielded a total of 161 responses (27%)—a minority of university researchers, but a response rate well above the expected 10–15% typical of digitally distributed qualitative survey instruments (see McGuirk and O'Neill 2016). The response rate also exceeded expectations given low levels of engagement with central evaluations generally at the university (arguably a function of time-poor academics increasingly flooded with emails to evaluate various university initiatives and functions). It may be that the sample and results discussed below are thus biased somewhat towards researchers with stronger positive or negative feelings towards the program, who felt compelled to reply, rather than those who are generally content with it, who did not. Even so, the survey sample generated sufficient breadth and diversity of responses to support qualitative analysis, which is the primary source of discussion in this article.

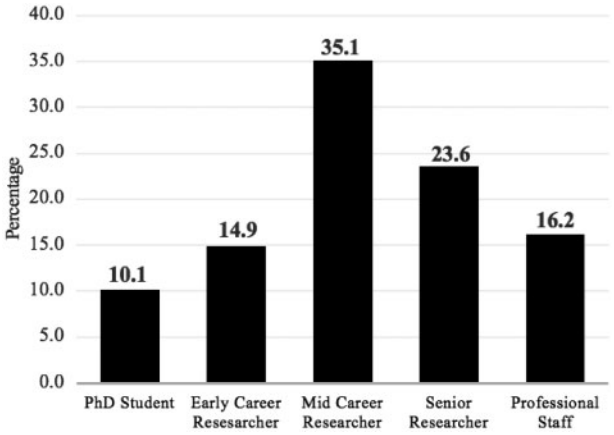

Figure 1. Survey respondents by career stage (n = 148). Percentage breakdown of responses to survey based on career stage of academic staff or grouped professional staff response.

Participants were not asked to enter their names into the questionnaire, but they were asked for information relating to their gender, career stage, and faculty affiliation. This was useful for providing an overview of the visibility of the program among different cohorts of researchers and faculties across the university. The majority of the survey respondents identified themselves as academic staff (75.8%), though there were some professional staff (17.4%) and students (6.7%) also represented. Of the total respondents, mid-career researchers were over-represented (35.1%), compared with PhD students, early career researchers, and senior researchers (less than 25% each) (Fig. 1).

In addition to baseline information, survey respondents were also invited to offer suggestions as to how the program might be improved to better foster interdisciplinarity among researchers. This formative, reflexive element is essential for building team research (Roelofs et al. 2018) and was a core objective of the study, geared towards allowing respondents to be as forthright as possible about their experiences (whether positive or negative) with the program.

The second data collection method, focus groups, commenced shortly thereafter, and involved a random selection of 25 researchers who had been involved in projects previously funded by the program. There were five focus group sessions in total and all were conducted on the university's main campus, facilitated by an independent researcher not a member of the program's leadership or research teams. Given that the online surveys were largely closed-ended, focus groups were an important opportunity for researchers to discuss in greater detail their experiences with the program. With the same reason in mind, researchers who were unable to attend focus group meetings were given the opportunity to be interviewed in a one-on-one setting. Subsequent semi-structured interviews were conducted by the independent researcher from March to April 2017, in the third and final data collection instrument employed for this study. A total of 11 interviews were conducted at locations chosen by the interviewee, some at the main campus and others at an off-shoot technology campus of the university. Each interview lasted

30–60 minutes and was audio-recorded to ensure the accuracy of transcription and later analysis.

Survey responses were cross-tabulated according to selected variables, with findings reported using descriptive statistics. The qualitative data were collected during focus groups and one-on-one interviews, then thematically analysed using NVivo software. This analysis followed the six-step iterative process outlined by Braun and Clarke (2006), beginning with the transcription of audio recordings and ending in the reporting of the research findings. A number of relevant themes emerged from the data analysis in relation to the overall efficacy of the program for fostering interdisciplinarity among researchers. Where interview excerpts appear as quotes within the article, pseudonyms are used in place of participants' actual names to maintain confidentiality.

4. Results

In its first 5 years of operation, the Global Challenges Program has generated some 108 new interdisciplinary research projects involving 464 unique researchers. This represents just under half of the full-time research/academic staff of the University involved in at least one project. Table 1 illustrates the program's engagement with researchers from all faculties across the university, as well as external engagement within the research projects. Higher levels of engagement with our Science Medicine and Health and Social Sciences facilities are indicative of the breadth of researchers in those faculties that could engage across a number of the projects funded by the program.

The program has also achieved success with gender equality, with females constituting 46% of named investigators and 43% of projects led by female researchers (Table 2). Early career researchers also comprise a notable percentage of project leaders (32%). From a base of A$2.7M (US$2M) in direct research funding provided internally through administered grant rounds in the first 4 years (a considerable sum for a regional university comparatively smaller in size), the program has attracted a total of A$26M ($US20.5M) from external grant funding (Fig. 2). Of particular note, the program has supported projects that have accessed significant funding pools (including non-profit medical foundations, philanthropic organizations, and government agencies) previously unfamiliar to participating researchers and new to the university. Several of these (e.g. Bill and Melinda Gates Foundation, Ian Potter Foundation, and Alzheimer's Australia) operate on the model of challenge-led funding, targeting specific problems with each annual round. Over a third of all projects have at least one named collaborating research investigator from external organizations (including community groups, health bodies, government agencies, and industry partners).

Table 1. Researcher engagement: the representation of faculty engagement as indicated by number of named investigators from each faculty on funded projects (n = 611)

Faculty	Percentage (%)
Business	8.7
Engineering and Information Science	14.2
Law, Humanities and The Arts	16.4
Science Medicine and Health	23.6
Social Sciences	20.8
External	10
Other (non-research staff at the university)	6.3
Total	100

Table 2. Research team compositions: (A) shows the composition of female, ECRs, PhD students, and external members as named investigators on funded projects. (B) Shows the composition of female, ECRs, PhD students, and external members as lead investigators on funded projects

Female	ECR	PhD students	External
(A) Composition of investigator teams, funded projects			
46%	21%	13%	9%
(B) Composition of lead investigator teams, funded projects			
43%	32%	1%	n/a[a]

[a]External collaborators cannot be a lead investigator on a research project.

Evaluation survey data gathered regarding the overall perception of the program demonstrate a suite of beneficial features (Fig. 3). They included its ability to promote interdisciplinary research; available staggered funding rounds that allow unique pilot programs to be trialled; the accessibility of its leadership team; and the leadership team's ability to facilitate and connect researchers from across different faculties. Some 90% of researchers felt that, overall, the benefits of interdisciplinary research outweighed the challenges.

When participants were asked to identify what aspect of the program design they found most appealing, the staggered funding structure was repeatedly nominated, for a number of reasons. The division of funding opportunities into levels with the possibility of scaling up from one to the next (along with securing external collaborations with government/community/industry organizations) was, for some, important for convincing collaborators to commit:

> I think it's nice having a combination to apply for, whether it's something small you're just trialling for a seed and then having success moving on to project. . . . I've had a seed and now a project grant and it's been good to have those options to really build this particular research area in that space (indigenous community) and then. . . looking at the next big grant to take it wider and further for the future. (Senior researcher)

As described among participants, the lower levels of funding provided a way for them to test ideas knowing it is okay to 'fail safely', without the added pressure of guaranteeing significant outcomes:

> I think the fact that it's low risk and small scale has really allowed it to blossom and move on to other things. We wouldn't have come

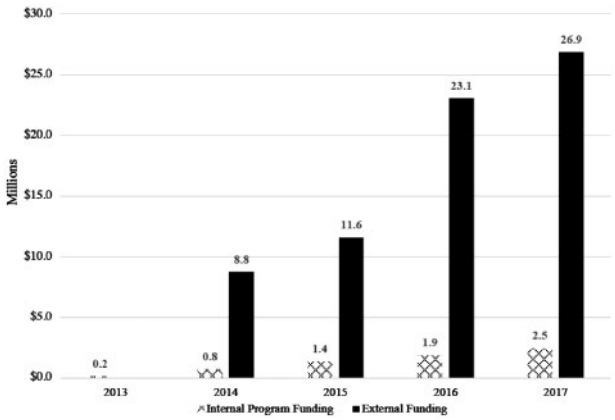

Figure 2. Cumulative investment and return on investment, 2013–2017. *These figures are self-reported and extracted from annual reports submitted by researchers.

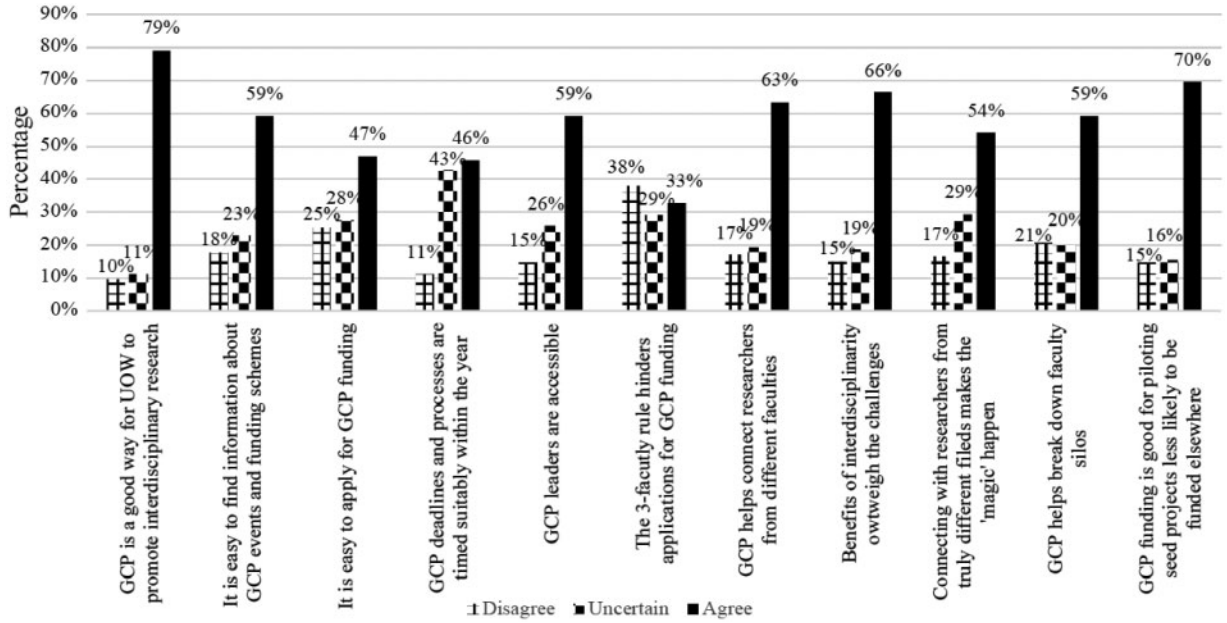

Figure 3. Overall perception of program (n = 135).

> together, wouldn't have thought up the research idea to try and go for an ARC project without that original (seed) funding, so I think it's really valuable to have that small scale and have the ability to fail if it doesn't work. … Not feeling like you received a large amount of money that you must deliver on… that's really important for moving knowledge forward. (Mid-career researcher)

Small seed grants also enabled 'exit strategies' for teams that did not gel:

> The other good thing with the seed… it gives you this exit strategy if it just doesn't work, and because it's a new team I think you need that exit strategy. Maybe also to get some of these people out of the Ivory Tower, it might be a way to pitch it to them and say, 'just spend a half a year, and turn up and see how you go and if you don't like it go back to your Ivory Tower'. (Senior researcher)

Meanwhile, the importance of interdisciplinary program and project leadership cannot be understated. Confirming insights from the broader interdisciplinary research literature, researchers benefited from transformational leadership (aimed at knowledge-sharing and conflict reduction), and collaborative leadership styles (Hüttermann and Boerner 2011; Bennett and Gadlin 2012; Baker 2015). Relationship brokering across Faculties was of paramount importance to researchers seeking to engage in interdisciplinary research, as well as leaders able to advise on other researchers who could potentially fit well within a proposed research project (Fig. 4).

The advice of the program's leadership team was vital to the success of several projects, including one on ecological impacts of shipping which has since scaled-up in size and ambition and is now being considered for a nationally funded industry linkage grant:

> …we had no idea who else was interested in shipping and ship movements and anchoring. We relied heavily on the understanding of the leadership to direct us to potential partners… because we don't know. So, I think even if we do recognise the potential for it to be interdisciplinary, it is very difficult to identify who might be interested. (Senior researcher)

Similarly, other participants pointed out that even when the researchers did not proactively seek advice regarding likely collaborators, the leaders recognized the need and advised accordingly. In other words, the program leaders did not always wait to be asked for support before they willingly offered it:

> What I've observed is that the team, to their credit, are going out of their way to be supportive. … If they notice the team is going down a direction that won't be successful, they seem willing to talk through it and say 'you must emphasise X, Y and Z'. I think that's an outstanding thing and it's not always something… the ARC (Australian Research Council) can't do that, external bodies can't… (Senior researcher)

Ongoing informal leadership support was also valued. In some cases, simply having informal conversations with the program leaders was important for troubleshooting challenging aspects of research projects:

> What I noticed that the Global Challenges team does very well is that they don't just read the application and approve or not approve it. They actually meet with the people and then suggest to them, 'So, do you know by the way that so and so in that faculty is working in this space?' (Senior researcher)

For researchers, it has been important that the leaders follow the principles of collaborative dialogism. Participants repeatedly indicated that talking to the leaders, whether formally or informally, often gave them the clarity and confidence they needed to overcome barriers that would otherwise have hindered progress.

4.1 Enabling distal interdisciplinarity: evaluating the 'three-faculty rule'

Opinion was divided on the program's requirement that research teams comprise representatives from at least three of the university's

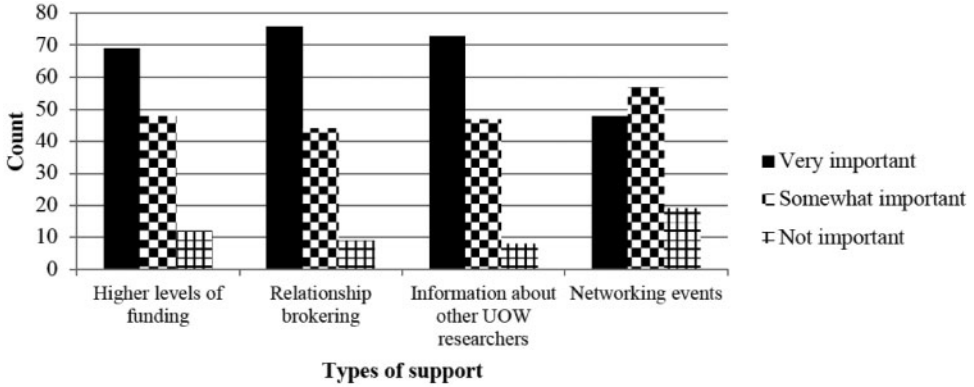

Figure 4. Overall importance ratings for support types (n = 133). Researcher response regarding the importance of the various types of support offered by the program.

five faculties to be eligible for funding (Fig. 4). Most participants expressed the view that while the rule may appear overly strict, it serves the important role of ensuring that collaborations are truly novel and not just 'teams of convenience'. The distinction, one participant explained, is that 'if you've got a Venn diagram and all the circles don't intersect, you've got multi-disciplinary, but if they overlap then you've got interdisciplinary'. When someone suggested that the three-faculty rule be 'loosened up' (based on disciplines rather than faculties), the same participant insisted that it might not achieve the same results because:

> If you just say disciplines, people can have really narrow ideas of what their discipline is and so they could get people from three different disciplines that are very closely related. (Senior researcher)

Being required to satisfy the three-faculty rule encouraged researchers to think well beyond their disciplinary boundaries and broaden their research scope. It led them to rethink not just the way they conduct research but also what contributions other (unlikely) disciplines could make to enrich the research agenda. As they saw it, the rewards of putting in the effort to collaborate with other faculties outweighed initial challenges the rule might impose:

> I'm an engineer, and every time I've done something with Global Challenges, I've expanded my horizons to social studies, engagement with consumers, neuroscience, all sorts of things that I was not exposed to before… one of the benefits of the program, is the ability to create interdisciplinary projects that you just can't fund any other way. (Mid-career researcher)

Beyond funding projects not otherwise supported by discipline-based schemes, distal interdisciplinarity provided a stimulating challenge personally to those researchers frustrated by the 'echo chamber' effect of collaborating only with others from the same discipline:

> It (three-faculty rule) forces you to get out of your own way, basically. So, I really enjoyed being twisted to go and find others to collaborate with because it's just too convenient just sitting in your faculty talking to like-minded people and for that I think it's great because I greatly benefited from it. (Senior researcher)

Other researchers questioned the need for such a rule, arguing that research does not have to draw from three faculties to distal or radical in interdisciplinarity. For some, the three-faculty requirement made for a very small pool from which to seek collaborators:

> When we had the 11-faculty structure [prior to a 2013 university-wide consolidation of faculties] the three-faculty rule made a lot more sense but now it's three-fifths of the entire uni… sometimes the cross-disciplinary between faculties is actually less strong than within our faculty. (Senior researcher)

Another stated that some might find the three-faculty rule off-putting because 'you have to learn to speak in a language that people in other disciplines can understand'. The discomfort that can arise in such situations has resulted in instability within a few project teams where researchers have disengaged or completely withdrawn from the project:

> Conceptually, what I thought the other disciplines would do, they've not done and I guess partly because I don't understand their discipline and maybe they're not understanding where I'm coming from… I don't think we've all got the same vision about where the project's going and a little bit of it is that we are all wanting to pigeonhole our research into this broader project without being a bit more flexible about what we do, I think… I'm not convinced it's meshing together well enough. (Mid-career researcher)

Lack of clear communication of researchers' roles prior to project execution can negatively impact project teams:

> …it's basically the two people who we thought might join the team have dropped off. …a forced redundancy from somewhere else meant that one of our persons left. Then the other person on our team didn't feel like she could contribute something to the project, it was a bit of an awkward situation where she's like 'Oh I don't think this project is going in the direction that I want.' … So, then she just sort of took a step aside. (PhD student)

Such interview excerpts highlight challenges to speak across fundamentally differing 'languages' and motivations that remain rooted in disciplinary research cultures (cf. Cheruvelil et al. 2014). In response, program leaders launched advertised weekly open drop-in sessions and informal coffee catch-ups (with individual researchers) to discuss ongoing tensions and/or developments; and where needed, organized, and facilitated project meetings to discuss conflicts. Advice was provided to researchers who might be struggling to find and/or keep collaborators. As the program evolved, research officers

were appointed to the program to provide stronger day-to-day support.

The three-faculty rule, while generating a degree of disquiet among some researchers (and definitional tensions within faculties), nevertheless had the desired effect of generating novel projects with often quirky topics (e.g. a shark-spotting beach blimp aimed at improving coastal safety and biodiversity outcomes; manufacturing innovation projects such as new condom designs, or 3D-printing atonal experimental musical instruments) from unlikely combinations of researchers who had not previously collaborated. What the three-faculty rule did not explicitly aim to support, and yet did catalyse, was another goal again: greater early-career engagement and leadership-building among the next generation of researchers.

4.2 ECR engagement: program design and human capital factors

While promoting early career researchers was an express goal of the program, the degree of subsequent engagement, and reasons for it, was unanticipated by program leaders. Analysing survey data and qualitative feedback from focus groups and interviews reveals that a combination of program design and human capital variables was key. The availability of small seed grants to fund riskier research and/or pilots, followed by staggered tiers of funding that scale into larger programmatic ventures, was an initial attractor:

> I'm still new when it comes to funding… but I like that scaling. Starting when you're maybe just having a small idea I think is nice, because that's quite rare to have funding being available to people to just pilot or try something. And then if it's risky, it doesn't work out, at least they've tried it. (Early career researcher)

For early career researchers, applying for program funding was likely their first funding application attempt; the staggered structure made it less daunting:

> I don't know how I would get money for any of the ideas, if it wasn't for Global Challenges, because it is so interdisciplinary. And I think particularly because the project is exploratory, and a lot of other funding programs you need to have pre-formed up ideas. (Early career researcher)

Somewhat more prosaically, funding lower-level but riskier projects helped build ECR's skills in research management:

> You don't necessarily have to have that track record to be successful in getting funding. But for me, it's also been a great learning experience in terms of trying to lead a project for the first time, working with other people. Even things like putting together a budget or writing up a report. (Early career researcher)

Successfully moving from seed to larger levels of funding was seen as a much-needed confidence boost to apply for external, larger funding:

> As an early career researcher, I think it's fantastic because it gave me the opportunity to get runs on the board. Starting off with seed and then I've progressed onto a project grant. That really provided me with an opportunity to explore an idea and then build on that idea… so I can be competitive for applying for those bigger grants… I thought it was really well targeted for early career researchers. (Early career researcher)

As one senior researcher succinctly put it:

> It's probably one of the few places where an ECR can apply without having to go for the great big hit, right? Nobody else is funding pilot programs. So you can try something out. (Senior researcher)

Participating ECRs positively evaluated the accessibility of leaders and their dialogic style of leadership. In the words of one ECR (since promoted to mid-career level), 'I think what's really good about it is the managerial style of the leaders. They're just very normal and approachable… just talk to you equally. That's very important'. Indeed, ECRs were consistently the most likely to take up opportunities for dialogue through drop-in sessions and workshops.

An unexpected factor informing improved ECR participation was the 'three-faculty rule'—intended instead to compel radical or distal interdisciplinarity. For ECRs, the compulsion to form eclectic teams was a challenge, but also a welcome opportunity to broaden horizons at an impressionable career stage:

> My area of research is around indigenous health, so the thing I've found the most challenging is that third faculty. How could they contribute? But the three-faculty rule has opened my eyes to like School of Business, how they could contribute in terms of doing cost-effective analysis in health research. So, it just brings a different dimension which I found good for my learning as well. (Early career researcher)

Especially revealing was the unanticipated confidence early-career researchers gained from being encouraged to lead projects, having 'gained permission' from the three-faculty rule to approach other researchers across campus:

> I was an ECR when I applied for the first one and I guess it gave me the green light to go seek collaborations… to go and approach people that you wouldn't normally feel like you could approach. … They (program guidelines) gave us the structure to say 'well, we need you because…' and we had our third faculty. (Mid-career researcher)

The three-faculty requirement was intended to pro-actively promote distal interdisciplinarity. But it also gave early-career researchers keen to develop new projects the impetus to seek unpredictable collaborations that would otherwise have been too daunting to initiate:

> The three-faculty rule really was helpful for initiating my project because that framework, that rule, gave me permission to approach people that at the time… much higher level than me: 'This is an idea I have… would you be interested in being part of it?' (Mid-career researcher)

ECRs faced similar difficulties to other researchers when seeking to combine efforts across epistemological traditions and languages.

> …if you don't have a plan early on, people can get angry or like later say 'I never agreed to do that'… We had, in terms of research questions, a discussion about 'this is what everyone will specialise in and can provide input about', and then in terms of what it would mean in terms of commitment, in terms of time… (Early career researcher)

In due course, relationships nurtured through such means resulted in several early- and mid-career researchers asking program

leaders and senior collaborating researchers to act as their formal mentors, beyond the scope of specific projects. Although not an explicit goal of the program, it in effect provided ECRs with pathways beyond the short term, in both building research projects and their careers:

> For me the Global Challenges Program made me feel like I was going to see this project to the end, and see real world results and it has actually done that… it's a great initiative and it's a really great platform for the research. (Early career researcher)

The above personal cases of career building and leadership development among ECRs attest to the benefits of taking a longer-term view. Distal interdisciplinarity in response to challenge-led funding promises not just to improve short-term grant funding successes, but to build longer-term thinking and careers.

Five years from its commencement, the review reflected on these various findings in contemplating the program's next phase. The university has overall been pleased with performance of the program. After the 5-year review, the program has been reinstated for another 5-year term, with an expanded budget (even within a tight funding environment federally). Structural changes ensued, including the creation of an additional challenge (responding to researchers' concerns for a flagship social justice focus), and an additional level of funding introduced well above the existing maximum (to improve chances of 'scaling up' successful projects to larger, program levels of external funding), along with revised guidelines incorporating deeper participation of faculty representatives in funding decision-making. Given that interdisciplinary research is a learning environment for all (Strang 2016), greater support has ensued for initiatives aimed at mutual learning about others. The roster of workshops, 'sandpit' meetings, and drop-in sessions has been expanded. A dedicated informal meeting space (advertised as a 'lounge', with comfortable furniture and access to a nearby and fully stocked kitchen) has been created and made available to researchers—in effect a 'neutral' space away from disciplinary settings. A major 2-day public conference bringing together researchers across faculties, universities, and participating external collaborating agencies was funded, and a marketing officer newly recruited to refresh and revise strategies to highlight and celebrate the successes of projects and key researchers.

5. Conclusion

Truly transformative interdisciplinary research remains complex and difficult. Organizationally, the challenge remains how to 'realize the latent potential of diverse teams' (Roelofs et al. 2018: 3), moving beyond cooperation among separate disciplinary researchers towards deeper integration of knowledge (Siedlok and Hibbert 2014) and more meaningful end user engagement (Crabtree 2017). Institutional stability is vital for success (Carayol and Thi 2005; McLeish and Strang 2014); yet flexibility and adaptability is needed to respond to ever-evolving funding rounds and the needs of end users. Culturally, the ongoing challenges include building leadership capacity, interpersonal teamwork skills, and overcoming assumptions about ideal pathways to build careers within and beyond disciplines (Hüttermann and Boerner 2011; Cheruvelil et al. 2014). Meanwhile, funding bodies concerned with realizing tangible impacts are increasingly shifting towards challenge-based models that are geared around specific societal and environmental problems. As the case of European Union program funding demonstrates (Brown, Deletic and Wong 2015; Ledford 2015; Rylance 2015; Van Noorden 2015), when larger, trans-/multi-/inter-disciplinary efforts work well, the rewards of broader collaborations, in terms of both funding scholarly and 'real world' outcomes, can be substantial. Exactly how universities and other research agencies are responding to such shifts remains an ongoing empirical agenda, to which this article has sought to respond through an evaluation of a program aimed at facilitating challenge-led distal interdisciplinarity.

Several aspects of the program evaluation confirm existing studies. Researchers identified the importance of transformational and collaborative leadership both at the program level, and within individual team projects (Hüttermann and Boerner 2011). Significant barriers included the difficulties of finding common ground across disciplinary traditions and languages, which required effective interpersonal skills and a collaborative rather than individualistic approach to knowledge generation and sharing (Cheruvelil et al. 2014). Dialogic leadership at the program level (brokering relationships, providing advice, and being highly accessible before and after funding application submissions) improved team cohesion and led to more successful publication and external grant funding opportunities (cf. Russell and Kelly 2002). Acting as curators and matchmakers rather than dictators, program leaders identified and introduced researchers from across disciplines and facilitated exchanges between researchers and external stakeholders, support which participants identified as being pivotal for their engagement in the program.

Beyond confirmation of existing research, this evaluation points to two key findings relevant to other institutions, as they adapt to the changing landscape of challenge-led funding among granting bodies. The first relates to the capacity to harness research projects in a grass-roots fashion, even while at the level of funding schemes the approach appears to be becoming more 'top down'. The program was initiated by, and retains strong support from, the senior executive of the university. Yet the program has not assumed line management responsibility for researchers who participate in its supported projects. While there is no obligation for researchers to engage in interdisciplinary research, there are benefits for them in so doing ('carrots' rather than 'sticks'). Because interdisciplinary teams can take a longer time to show a return on investment (Van Noorden 2015), a structure of tiered funding was adopted. Researchers especially valued this, with initial seed funding at low levels for high-risk projects, pilots, and untested ideas (and for teams with no prior collaborative track record), scaffolding to larger amounts, as outcomes were proven and external opportunities identified. Dialogic leadership again here assisted: providing early feedback on nascent ideas, advice on new team members, or imminent funding opportunities. Such insights suggest that in building such programs, universities, and other research agencies will need to invest properly in both internal funding levels (across sufficiently long time spans to witness outcomes) and program leaders, freeing up their time to provide the ongoing dialogues characteristic of collaborative and transformational leadership.

The second relates to distal interdisciplinarity and the benefits that arise from program guidelines and dialogic leadership styles—not just for generating new teams of unlikely collaborators but for achieving other goals such as the promotion of next-generation researchers. In this case, ensuring eclectic combinations of researchers to maximize benefits from combined differences (cf. Davids and Frenken 2018) meant imposing a strict guideline on faculty representation on research teams. That in turn elicited a degree of dissent

among researchers, especially from within faculties that already possessed internal diversity. Nevertheless, when researchers responded to the strict guideline and did build novel combinations, they consistently pointed to the benefits of distal interdisciplinarity for pursuing new projects entailing deeper syntheses of knowledge (cf. Larivière, Haustein and Börner 2015). Moreover, strict guidelines ensuring true difference among research teams also generated other benefits, especially for early-career researchers. Low tiers of funding where it is acceptable to fail plus clear guidelines promoting ECRs into leadership positions on teams were essential. But critically, these factors combined with supportive dialogic leadership and strict guidelines on disciplinary diversity to encourage ECRs to approach senior collaborators (rather than assuming that the reverse would ensue).

It is possible, then, to reconcile the increasing shift towards challenge-led, problem-orientated research funding, with researchers' motivations and the exigencies of building careers differently within an increasingly competitive higher education system. A combination of program design, strong articulation of academic values, and preference for a dialogic rather than 'hands-off' approach to research management prove key.

Notes

1. Summarizing previous discussions on how to build, conduct, and describe research across multiple disciplines is beyond the scope of this article (see instead Klein 2008; Bammer 2013; Yegros-Yegros, Rafols and D'Este 2015; McLeish 2016 for overviews of the debates). In lieu of advocating a singular definition for interdisciplinary research, the following useful descriptor comes from the US National Science Foundation (NSF): 'a mode of research by teams or individuals that integrates information, data, techniques, tools, perspectives, concepts, and/or theories from two or more disciplines or bodies of specialized knowledge to advance fundamental understanding or to solve problems whose solutions are beyond the scope of a single discipline or area of research practice'.
2. Global Challenges Program leaders do not have authority to re-write staff promotion guidelines for the university to explicitly reward interdisciplinary research participation. Nevertheless, because the program became the major strategic research initiative of the university, participation in it thence 'counted' towards an individual's promotion chances. The university's promotion system adopts a 'whole-of-person' case approach in light of the university's strategic goals, rather than being driven by metrics alone. Several early-career researchers' promotion to higher levels has since rested on cases of Global Challenges Program-supported research where they exhibited initiative leading to successful outcomes.

Conflict of interest statement. None declared.

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